St. Petersburg University

Graduate School of Management

[Master in Corporate Finance]

APPLICATION OF MONTE CARLO SIMULATION IN RESIDUAL EARNING MODEL FOR IPO-PRICES ESTIMATION

Master's Thesis by the 2nd year student

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Я, Евстафьев Егор Витальевич, студент второго курса магистратуры направления 38.04.02 - «Менеджмент», заявляю, что в моей магистерской диссертации на тему «Применение имитационного моделирования по методу Монте-Карло в модели остаточной прибыли для оценки цены IPO», представленной в службу обеспечения программ магистратуры для последующей передачи в государственную аттестационную комиссию для публичной защиты, не содержится элементов плагиата.

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Мне известно содержание п. 9.7.1 Правил обучения по основным образовательным программам высшего и среднего профессионального образования в СПбГУ о том, что «ВКР выполняется индивидуально каждым студентом под руководством назначенного ему научного руководителя», и п. 51 Устава федерального государственного бюджетного образовательного учреждения высшего образования «Санкт-Петербургский государственный университет» о том, что «студент подлежит отчислению из Санкт-Петербургского университета за представление курсовой или выпускной квалификационной работы, выполненной другим лицом (лицами)».

(Подпись студента)

(Дата)

ABSTRACT

Master Student's Name	Egor Evstafev
Master Thesis Title	Application of Monte Carlo simulation into Residual Earning model for IPO prices estimation
Faculty	Graduate School of Management
Major subject	Management
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Academic Advisor's Name	Tatiana A. Garanina
Description of the goal, task, and main results	The main goal of this master thesis is to test applicability of Monte Carlo simulation into residual earnings model for IPO-prices evaluation on LSE and LSE AIM and compare it with the original residual earning model in terms of explanatory power over actual IPO-prices. To achieve this goal, the following research objective should be reached: 1. Study the theoretical background on IPO process and financial valuation models; 2. Analyze previous researches on application of Monte Carlo simulation in financial valuation; 3. Propose an empirical methodology for the analysis of simulated residual earning model and its explanatory power over real market values; 4. Acquire and describe a sample and conduct an empirical study; 5. Interpret the results and provide managerial application based on the key findings. For the empirical study, the sample of 58 companies went through IPO process on London Stock Exchange and London AIM Stock Exchange over the period from 2010 to 2017 was taken. The data regarding IPO deals and financial accounting numbers was collected from Zephyr and Thomson Reuters databases. The conducted tests show that both models set unbiased estimation of company's market value on the IPO date. The research findings indicate that incorporation of Monte Carlo simulation lower the variance of estimation and, thereby, increase the accuracy of the residual earning model valuation. It was also shown, that the application of Monte Carlo simulation has additional advantages due to the structure of the model itself.
Keywords	Monte Carlo simulations, Residual earning model, IPO, Nontraded companies, LSE, LSE AIM

АННОТАЦИЯ

Автор	Евстафьев Егор Витальевич
Название магистерской диссертации	Применение имитационного моделирования по методу Монте-Карло в модели остаточной прибыли для оценки цены IPO
Факультет	Высшая Школа Менеджмента
Специальность	Менеджмент
Год	2018
Научный руководитель	Гаранина Татьяна Александровна
Описание цели, задач и основных результатов	Цель данного исследования – проанализировать применимость имитационного моделирования по методу Монте Карло в модели остаточной прибыли для оценки цены IPO компаний, вышедших на торги на фондовых биржах LSE и LSE AIM. Задачи исследования: 1. Изучить теоретические основы процесса IPO и модели финансовой оценки; 2. Проанализировать предыдущие эмпирические исследования применения моделирования Монте Карло для финансовой оценки; 3. Разработать методологию исследования для анализа модели остаточной прибыли с использованием моделирования Монте-Карло; 4. Составить и описать выборку компаний для эмпирического исследования; 5. Проанализировать результаты и сделать выводы для практического применения результатов исследования. Для данного исследования была использована выборка из 58 компаний, совершивших IPO в период с 2010 по 2017 год. Данные о сделках IPO и финансовых отчетах компаний были собраны в базах данных Zephyr и Thomson Reuters. Согласно результатам исследования, обе модели устанавливают несмещенную оценку рыночной стоимости компании на момент IPO. Проведенные тесты показывают, что использование моделирования Монте Карло снижают дисперсию оценки и, тем самым, повышает точность модели остаточной прибыли при оценке цен IPO. Было также показано, что применение моделирования методом Монте Карло имеет дополнительные преимущества из-за структуры самой модели.
Ключевые слова	Моделирование Монте Карло, Модель остаточной прибыли, IPO, Неторгуемые компании, Лондонская Фондовая Биржа

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INTRODUCTION

Taking into account the fact that the main goal of any company is to increase its value in the interests of shareholders, nowadays the initial public offerings (IPOs) are one of the reliable and proven ways to increase financial opportunities for companies. Due to the rapid growth of the economies of developing countries and the formation of their stock markets, there is a trend towards an increase in the number of firms going public. This brings attention to companies' IPOs from both theoretical and practical points of view. Moreover, the relevance of this issue is justified by the fact that IPO process has a number of specific problems that should be addressed.

It is well known that an IPO involves problems regarding price discovery. The market is not certain about the quality of the IPO firm, while the issuing firm does not know the market demand for its shares. Issuers, therefore, delegate the offer price decision to an investment bank that underwrites the IPO (Baron, 1982). In order to make an estimation of companies' fair market value, underwriters normally use several valuation methods and then combine the value estimates of the different methods in estimating the fair value of the IPO shares.

The residual earning model (RE model) is one of the income-based valuation approaches which are broadly used methods for evaluation of the fair value of a company. However, these approaches present a number of serious weaknesses, one of which is tackling the uncertainty that characterizes future performance of a company. By utilizing probability-based valuation models and recognizing a probability distribution of key residual income drivers using Monte Carlo simulations (MC simulations), uncertainty can be incorporated into the residual earning model and shortcomings of the traditional model can be addressed.

Thereby, the thesis will study whether this combination provides investors, company managers and other related decision makers with more accurate information regarding the actual market value of companies on the IPO dates and how additional advantages of simulated residual earning model over the original model can be used while making a decision.

According to PriceWaterhouseCoopers and Ernst&Young annual IPOs overview, for the recent years, London Stock Exchange was one of the most popular choices for companies' IPO and topped European list of stock exchanges in term of number of IPOs. Due to this fact, public traded companies went through the IPO process on London Stock Exchange and London AIM Stock Exchange in the recent years were chosen as the object of the research. The subject of the research is the applicability of residual earning model in conjunction with Monte Carlo simulation for evaluation market value of non-traded companies which are going to raise capital

through IPO. Thus, the aim of this paper is to test the applicability of Monte Carlo simulation into residual earnings model for IPO-prices evaluation on LSE and LSE AIM.

The research goal can be broken down into the following research objectives:

1. Study the theoretical background on IPO process and financial valuation models;
2. Analyze previous researches on application of Monte Carlo simulation in financial valuation;
3. Propose an empirical methodology for the analysis of simulated residual earning model and its explanatory power over real market values;
4. Acquire and describe a sample and conduct an empirical study;
5. Interpret the results and provide managerial application based on the key findings.

There are two options how to approach the empirical results of the thesis. The first approach assumes that the observed market value is sufficient for determining a firm's value. Thus, the value of a firm observed in the market should be used as a benchmark against the conducted analysis and the feasibility of the valuation model. The second approach implies that firm's value is indicated in its published financial statements. Thus, the intrinsic value of a firm derived from published financial statements serve as a benchmark against observed market price and interpretations about possible over- or underpricing of the stock. The thesis will be founded on the first approach. Therefore, the research questions of the thesis are as follows:

1. Does the original earning model generate accurate expected market value of a company on the IPO date?
2. Does the simulated residual earning model generate accurate expected market value of a company on the IPO date?
3. Does the simulated residual earning model provide related decision makers with valuable additional information on a market value of a company on the IPO date in comparison with original residual earning model?

The paper has the following structure: introduction, Chapter 1 is devoted to the theoretical background of IPO process, methods of financial valuation, and fundamentals of Monte Carlo simulations; Chapter 2 is devoted to the empirical study, results interpretation, and conclusion.

CHAPTER 1. IPO PROCESS AND VALUATION

1.1 IPOs: theoretical background

An IPO can become a very profitable source of financing for a company. In order to further analyze valuation technics applied to IPO valuation, this chapter first studies the theoretical concept of IPO, implementation mechanisms, as well as advantages and disadvantages.

Two broad categories of companies can be distinguished: privately-held and public companies. Although large firms can also be private, the IPO represents the first significant stage in the evolution of a public company. When high growth mid-sized companies transition into established global players, public markets are vital (European Commission, 2015). In the post-issue phase, the IPO firm can evolve into one of three basic states: (1) survive as an independent firm, (2) get acquired and lose its current identity, or (3) fail outright (Jain and Kini, 1999).

An entrepreneurial concept or idea is initially funded with private equity capital or debt. In later stages in the development of a company, it will try to raise money for expanding its business into the broadest set of funding providers' sources, such as retained earnings and, eventually, by issuing equity to the public (Jain and Kini, 1999).

As it was mentioned in the Introduction, IPOs are the first time that a company sells shares in the stock market (Megginson and Weiss, 1991). The company either issues new shares or sells existing ones, where the proceeds of selling new shares help to raise capital for the company, and the sale of existing shares are accrued to the original investors (Jenkinson and Ljungqvist, 2001). Issuing shares for public investors is one way of raising public equity, which means a company is selling shares of control of the company to public investors in exchange for capital (Brennan and Franks, 1997). From the perspective of constructing assets, raising equity capital contrast with raising debt capital: the former grants investors rights to vote and to receive dividends according to the company's dividend policy and profit in a given fiscal year; the latter grants the creditors fixed interest payments regardless of the company's profit in a given fiscal year (Frank and Goyal, 2003). In an IPO, because public investors buy shares conferring control over a company after the new shares are issued, the company's ownership status changes from privately owned to publicly owned (Deeds et al., 1997).

IPO has become one of the most popular ways for companies across all industries and company sizes to acquire additional equity. It is, therefore, also one of the most popular topics for researchers. From the beginning of the last century, interest in the topic has resulted in many

publications in this particular field of finance, with contributions from all over the world and on many different areas of IPO.

1.1.1 IPO process overview

There are three parties involved in the IPO process: issuers, underwriters, and investors. In short, the IPO process can be described as issuers recruiting underwriters to organize and sell the shares, while the shares are ultimately allocated to investors in the primary or secondary market (Jenkinson and Jones, 2009). With respect to their activities over time, these three parties are active in three phases and two markets throughout the IPO process. These three phases and two markets include: 1) preparing to go public, 2) allocating IPO shares in the primary market, and 3) trading the shares in the secondary market (Alavi et al., 2008).

During the preparation phase, issuers and underwriters are the most active parties. During this stage, the main tasks for issuers are preparing their companies both financially and strategically for the IPO. The main tasks for underwriters include preparing relevant documents, such as filling the forms, officially required by the regulators, and preparing the preliminary prospectus that discloses necessary information on the issuer (Bhabra and Pettway, 2003).

Timeline of the IPO process is summarized in the Table 1. As it was mentioned before, three main parties – issuers, underwriters and investors – and two markets – primary market and secondary market – are involved in the process. Issuers and underwriters are active in the first stage – primary market; underwriters and investors are active in the second stage – secondary market; finally, all three parties are involved in the IPO process on the date of the public offering. All three involved parties are focused on their own goals that are discussed further.

After the preparation is completed and the regulators approve the IPO, the focus of the IPO process shifts to share allocation, which takes place in the primary market. During this phase, issuers and underwriters allocate the IPO shares to investors (mostly institutional investors) before the shares become publicly tradable in the secondary market (Jenkinson and Jones, 2009). The market in which the IPO shares are firstly allocated is known as the primary market. After the primary market ends, IPO shares are made available to the public investors, and this is when the secondary market becomes active. In the secondary market, shares can be freely traded among public investors, and typically when people refer to the stock market, they are referring to this secondary market (Mauer and Senbet, 1992).

Table 1. Timeline of the IPO process and involved parties.

Stage of the IPO process	Involved parties
Primary Market	Issuers, underwriters
Date of public offering	Issuers, underwriters, investors
Secondary market	Underwriters, investors

The following are the key objectives of the company going public: maximization of attracted additional capital, satisfaction of investors' interests by increasing the value of shares, facilitation of future financing, improvement of the company's business reputation by conducting a successful IPO (Espinasse, 2011). The key objective of underwriters is the maximization of their revenue and increase of its business reputation by completion of successful IPO under its leadership. Finally, investors are focused on maximization of stock returns in both short-term and long-term perspective, expansion, and diversification of their investment portfolio and acquisition of shares of attractive companies.

Thus, it can be noted that the interests of the resigned parties coincide in terms of achieving the maximum level of income. This, in turn, is closely related to the correct valuation of the company before the IPO, the company's successful financial results after the IPO and the high liquidity of the shares in the secondary market.

1.1.2 Advantages and disadvantages of IPO

Like any money-raising facility, the initial public offering has several advantages and disadvantages. According to (Bancel and Mittoo, 2009), the decision to go public has important consequences for the firm, as it subjects the firm to the enhanced disclosure and regulatory requirements of stock exchanges, as well as to the intense scrutiny of analysts and the media. After summarizing the benefits and costs of going public, the authors assert that companies going public perceive long-term benefits to significantly outweigh the costs related to IPO process. That in some way explains why many privately owned companies all over the world have become public.

The main benefits that the company receives after IPO include but not limited to:

1. *Large capital inflows* (the possibility of attracting a significant amount of money that does not require a return and is not limited in time to use; (Bancel and Mittoo, 2009) stated that attracting capital for business growth is indeed the most important benefit to a company going public);

2. *Growth of liquidity and shares price* (publicly traded companies are valued more than their non-traded competitors, since the information contained in the IPO prospectus and subsequent annual reports reduce the uncertainty regarding the performance of the company, and, thereby, increase its value);
3. *Increase of business reputation* (the greater transparency and openness of a publicly traded company improves its image; in addition, the presence of a listing on a large stock exchange allows the company to attract more qualified human resources due to the fact that work in such a company is considered more attractive and prestigious);
4. *Motivation for management and employees* (the possibility to introduce rewards in the form of share options and premiums in the form of shares to attract and retain highly qualified employees);
5. *Access to alternative sources of capital* (publicly traded companies have more favorable conditions for attracting additional sources of capital, such as lower cost debt and simplified way of obtaining debt);
6. *Indirect benefits* (improvement of the company's management and financial structure in preparation for the shares issue as well as a clear formulation of the business strategy for the IPO prospectus development contribute to the company's further success).

Moreover, (Ritter and Welch, 2002) stated that IPOs also generate a public market where the current shareholders can convert some of their wealth into cash at a future date by making it possible to sell their share of the company to the public. It thus also provides an 'exit route' for the company's original founders and investors (Jenkinson and Ljungqvist, 2001).

Despite such a wide range of advantages, the IPO also has certain drawbacks. These include but are not limited to:

1. *Increase in transparency* (an increase in the number of people who have access to company reports may have a negative impact on the interests of existing owners and managers; in addition, publicly traded companies are subject to increased public interest, any negative information will be associated with serious reputational risks);
2. *High costs of IPO* (the process of issuing new shares requires considerable expenditure, both initial in the form of a commission to underwriters and payment for the service of lawyers and accountants, and additional ones in the form of expenses for advertising and promotion);
3. *Separation of ownership and management* (managers act on behalf of and in the interests of shareholders, control over compliance with the rules is exercised by the board of

directors of the company; that is, it imposes certain restrictions on the activities of managers);

4. *Possible loss of control over the company* (transition of control over time to a broad mass of shareholders or a hostile majority shareholder);
5. *Necessity to justify investors' expectations* (holding meetings to discuss the company's development strategy, results and future perspective with current shareholders);
6. *Focus on a short-term result* (choice of a strategy aimed at maintaining a high stock price in the short term, disregard of the company's long-term strategy).

Summarizing the above, it should be noted that the process of the initial public offering of shares is quite labor-intensive from both financial and managerial point of view for the companies going public. However, in the modern economic environment, the desire of firms for growth and development contributes to the widespread use of IPOs as a way to increase their financial capacity. However, (Ritter and Welch, 2002) noted that there still remain questions regarding whether IPO is the best way to raise capital, considering the strict legislation, and why the companies' motivation to perform an IPO is stronger in some situations and at some times then it is in others.

1.2 Approaches to IPOs valuation

Despite only a few companies spend enough resources to obtain an understanding about the value of their business, having an accurate estimation of business value is essential, especially for companies that are going to conduct the IPO. It allows owners of the company to organize the financial management in a more efficient way and allocate the necessary amount of money for reinvestments into the business to ensure a stable and consistent growth of the company. This becomes more essential when a company is going public in order to determine an accurate estimation of company's value, set a fair offer price and, thereby, attract the highest possible capital.

1.2.1 Overview of valuation methods

The most common companies' valuation methods might be split into the three general groups: asset-based, market-based, and income-based approaches. The following presentation of the valuation models, discussion of their peculiarities and applicability in this master thesis is based on (Damodaran, 2006) and (Volkov, 2008).

Asset approach looks at a company as on a set of assets and liabilities the company has and use this information for business valuation. One way to estimate the value of a company is to

calculate the market price of its assets for which they can be sold in case of company liquidation (so-called exit value approach). Another way (so-called entity value approach) is based on the economic principle of substitution and tries to answer the question: how much would it cost to buy an identical or similar asset that generates the same profit for its owners? However, none of these methods take into the account the perspectives for future development of the business and can be barely used for IPO valuation.

As the name suggests, the market or relative approach relies on market realities and follows an economic principle of competition. It sets the question: what similar businesses are worth? The market approach values a business by comparing with the other companies. For comparable companies' analysis, it is usual to select public traded companies that are operating in the same or similar industry as the company to be valued. However, the difficulties related to the search of comparable and the inability to find a company that would be exactly the same as the valued company, pose limited usefulness of this approach.

Income approach looks at the business from flow making stand-point (income, cash or dividends). It applies an economic principle of expectation and sets the question: when and what economic benefits a company will generate in the future? The most commonly used models are Discounted cash flow model (DCF model), discounted dividend model (DD model) and residual earning model (RE model).

Discounted dividend model was firstly introduced in (Williams, 1938), and then significantly developed in (Gordon, Shapiro, 1956) and (Sharpe, Alexander, Bailey, 1995). The model is based on the following principle: the fair value of the security should equal the present value of the cash receipts expected from this security. The owner of the company's shares receives financial income in the form of dividends paid by the company. Therefore, this model determines the value of the company as a discounted flow of expected dividends.

Discounted cash flow model is one of the most commonly used models and is described in a wide range of the literature (Brealey and Myers, 1991; Benninga and Sarig, 1997; Damodaran, 1996 and others). The main idea of the model is that the company's value is determined by the discounted free cash flows generated by the company. Volkov (2008) notes that the discounted cash flow model emerged as the development of a discounted dividend model: while the DD model considers payments only to equity providers, the DCF considers payments to suppliers of both own and borrowed capital. Moreover, the author proves the equivalence of these two models under certain assumptions. As a result, this model determines

the value of the company as the difference between the discounted cash flows generated by the company and the market value of its debt.

Originally, the residual earning model was presented by a range of authors (Preinreich, 1938; Edwards and Bell, 1961; Miller and Modigliani, 1961; Fama and Miller, 1972; Peasnell, 1982), but it was Ohlson (1995) who brought the model to the center of the discussion as an equity valuation method. The model assumes that the company's value is determined by four factors: the amount of invested capital at the time of valuation, the actual and required return on capital, and the ability of the organization to yield a return on capital above the required. The central concept of this model is the concept of residual earning (RE) – the difference between net profit of the company and the cost of equity used for generating the profit. As the result, the model determines the value of the company as the sum of the book value of equity at the time of valuation and the discounted flow of residual earnings. The description of the model and its application, as well as the incorporation of Monte Carlo simulation in the residual earning model is described in detail in the second chapter.

Each of the above methods will generate different values. One method will be more appropriate to a kind of business valued than the other depending on the availability of the data for forecasting, specificity of the industry the business operates in, and investors' expectations of the industry growth. The main differences among these models, their applicability and accuracy are discussed in more details in the following sub-section.

1.2.2 Comparison of residual earning model with other valuation methods

The literature is rich in papers examining the accuracy of different valuation models and questioning the superiority of one model over others. The issue is still controversial. This subsection firstly discusses the relative valuation approach and then compare three income-based approaches described previously among each other.

Multiple valuation approach

The advantages of a multiple valuation of a company are usually attributed to the fact that this approach is easy to understand and use in practice, implies fewer assumptions than other valuation methods and better captures the current mood of investors regarding the state of the market. Despite many authors (Rosenboom, 2007; Deloof et al, 2009) claim that multiple valuation is by far the most used method for IPO valuation, this method certainly has several disadvantages that cannot be neglected.

The main disadvantage of multiple valuation is its sensitivity to choice of comparable companies. This is supported by (Alford, 1992) and (Bhojraj and Lee, 2001), who emphasized the importance of choosing the right set of comparable companies. However, it might be difficult to find comparable companies operating in the same region, industry sector and having identical or at least similar revenue drivers. This issue implies that the multiple valuation is a powerful approach in developed markets with many public traded company but is inapplicable to emerging markets simply because finding a true comparison can be problematic.

Another open question regarding the application of the multiple valuation is a choice of a right set of multiples. The most commonly used multiples are price-to-earnings (P/E) ratios, price-to-book (P/B) ratios, and price-to-sales (P/S) ratios. A large range of literature (Kim and Ritter, 1999; Yoo, 2006) is devoted to the choice of right multiples. (Kim and Ritter, 1999; Ely et al., 2007) suggested that using industry-specific multiples for valuation could result in more price estimations closer to the observed market price.

Some academics (for instance, Damodaran, 2006) claims that multiple valuation generally yields better values that are closer to the market price than income-based valuation approaches. However, some research (Kaplan and Ruback, 1995) shows that both approaches set similarly accurate estimations of market value.

Income-based valuation approaches

According to some researchers the RE model has better results, it can more precisely estimate the value than the models based on the discounted dividends or discounted free cash flows (e.g. Bernard, 1995, Lee et al., 1999, Penman and Sougiannis, 1998, Francis et al., 2000). This conclusion usually refers to the model's reliance on earnings and book value predictions over relatively short time periods as compared with the longer time periods needed in the DCF and DD models, its independence from capitalizing research and development costs. Another advantage of RE model is its ability to specify the relation between market values of equity and accounting information such as earnings and book values on a theoretical basis (Lo and Lys, 2000). However, Myers (1999) questions the empirical evidence from a purely pragmatic point of view: "Theory may be irrelevant and the proof of the model is how well it approximates stock prices".

Other researchers (e.g. Lundholm and o'Keefe, 2001) declare that there is no sense in comparing these methods because they have a theoretically common basis, thus, if one model gets a more precise value, it cannot be stated that this model is more effective or more precise than another one. The authors also conclude that all income-based approaches have the same

underlying assumption and the differences in their outcomes imply the difficulty of applying the same input assumptions to different models and conclude that neither of the models is superior to one another.

(Volkov, 2008) proves the equivalence of discounted cash flow, discounted dividends, and residual earning models under certain assumptions and emphasizes that the equivalence of models does not mean that models are equivalent in terms of their applicability. In this sense, the question arises as to which of the presented models can best be used for IPO valuation.

It is well known that an IPO involves problems regarding price discovery. Issuers, therefore, delegate the offer price decision to an investment bank that underwrites the IPO (Baron, 1982). Since underwriters repeatedly bring firms public, they have strong incentives to build a reputation as a valuation expert and certify that the offer price reflects fundamental value (Ibbotson and Ritter, 1995). In practice, underwriters determine an estimate of the fair or market value of the IPO firm's equity, which serves as a basis for setting the preliminary offer price. For this purpose, underwriters normally use several valuation methods and then combine the value estimates of the different methods in estimating the fair value of the IPO shares.

1.2.3 Overview of anomalies related to IPO pricing

Although this master thesis is devoted to the application of Monte Carlo simulation in the residual earning model, this subsection introduces a number of basic anomalies related to valuation of IPOs. There are three main phenomena that are studied in the analysis of IPO efficiency: IPO underpricing, long-term underperformance, and cyclical nature of IPOs. All three phenomena are briefly discussed below.

Initial IPO underpricing

IPO underpricing is the case when a company's shares are issued at an undervalued price, which leads to a significant increase in prices on the first trading day. This might be beneficial for investors due to the rapid growth of shares prices and high financial returns. On the other hand, it means that the issuing company had the opportunity to attract more capital, but failed to do that. The most popular theories see the asymmetry of information as the main reason for IPO underpricing. The asymmetry of information has twofold interpretation: investors are better informed about the demand for the issuer's shares, while the issuer itself has more information about the activities of its company.

In (Rock, 1986; Benveniste and Spindt, 1989; Hanley, 1993) the authors analyzed a model in which some investors possessed more information than the other. The conclusion was

made that institutional investors have insider information and know the true value of the stock, while less informed investors make their decisions on the basis of expectations, resulting in the initial underestimation.

As an alternative explanation for IPO underpricing is proposed in (Welch, 1992). The author claims that investors make decisions on the acquisition of shares, taking into account the actions of investors who have already negotiated with underwriters earlier. Proceeding from this, inflated offer prices can cause the failure of IPOs due to unsuccessful negotiations with the first investor. The author explains that issuers and underwriters deliberately discount the company's fair value to set the preliminary offer price of the shares. According to (Roosenboom, 2007), this discount is higher for IPO firms with greater valuation uncertainty and lower for companies that are brought to the market by more reputable underwriters and that are forecasted to be more profitable.

Summarizing the above, it can be concluded that the initial underpricing of company's shares as a result of IPO takes place in both developed and emerging markets, and the asymmetry of information is the most significant and popular factor in explaining its existence.

IPO long-term underperformance

This phenomenon refers to the situation when the shares of companies that have conducted the IPO on the long-term time horizon show a lower profitability compared to the shares of similar companies that did not conduct the IPO. Despite a large number of studies, the question of the reasons for the IPO long-term underperformance remains unresolved. One of the most commonly used explanation is that there are periods in the market when investors are overly optimistic about the future performance of the companies going public. Increased demand for shares leads to a higher initial price and, consequently, a lower financial return in the long term.

The first attempt to explain the long-term underperformance of IPO was made in (Miller, 1997). According to the author, during an IPO, the shares are purchased by the most optimistic investors who offer the highest price for them. Meanwhile, over time, the valuation of shares by the most optimistic investors tends to average on the market due to the understanding of the true situation. This leads to a decrease in shares price and, consequently, lower long-term profitability. Loughran and Ritter (1995) specify that investors tend to overestimate the future performance of small- and medium-sized companies that initially grow at high rates.

On the other hand, newer works disagree with the findings of previous researches. For instance, Gompers and Lerner (2003) and Otcher et al. (2013) use a different approach to calculate shares profitability and do not find evidence of the IPO long-term underperformance. According to the authors' conclusion, the results of the analysis depend on the instruments used for the research.

Cyclical nature of IPOs

The issuance activity of companies is subject to significant fluctuations from year to year, which is expressed in a large number of placements in one year and significantly less in others. This fact suggests the existence of a so-called window of opportunities in the capital market and the cyclical nature of the initial public offering.

The earliest work analyzing the phenomenon of cyclical IPOs is (Lucas, McDonald, 1990). The authors illustrated that the management of the company waits for a favorable moment when investors' expectations and their moods will allow them to get the highest price per share, and only then conduct an IPO. This is supported by (Ibbotson et al., 1994; Ritter, 2003) who stated that there are periods when investors tend to overestimate the company's value. A company conducting an IPO at such periods can attract a much larger amount of capital than what it actually can claim for. On the other hand, at other periods, the company’s value might be underestimated, depending on investors’ expectations.

Several studies have examined the relationship between the number of IPOs and the dynamics of the financial market (Ritter and Welch, 2002) and periods of increased underestimation of companies (Lowry et al., 2002). Despite the different objects of analysis and the assumptions made for research, all authors agree that companies choose to go public in periods that allow them to attract as much money as possible.

The studies discussed above allow us to conclude that stock markets are influenced by investors’ expectations regarding the market and/or industry opportunities for growth, and such a significant event as the IPO is not an exception. Another important observation is that the three key phenomena discussed in this subsection are closely interrelated: the main causes of anomalies are the asymmetry of information and the dependence of stock markets on investors' expectations.

The author acknowledges that anomalies described in this subsection have a direct impact on the IPO process and only increase the difficulty of accurate estimation of IPO-prices. However, this master thesis is focused on the analysis of the residual earning model and

application of the Monte Carlo simulation in this model. Although the analysis of IPO anomalies and reasons behind them lies out of the scope of this study, the main conclusions discussed in this sub-section will be useful for the development of managerial application based on the findings of the thesis.

The market is not certain about the quality of the IPO company, while the issuing company does not know the market demand for its shares. It is common practice to use several valuation methods and then combine the value estimates of the different methods in estimating the fair value of the IPO shares. As it was mentioned before, all income-based valuation approaches require to make forecasts of the future models' key variables and, therefore, deal with the problem of uncertainty of the future. Traditional and modern approaches to uncertainty analysis are discussed in the following section.

1.3 Uncertainty analysis

This section introduces the basic concepts of the three most commonly used in the analysis of uncertainty. Traditional methods consist of sensitivity analysis and scenario analysis, the simulation method is a newer and more advanced approach. The way of how Monte Carlo simulations might be applied to the residual earning model and firm valuation in general is discussed in the following section.

1.3.1 Sensitivity and scenario analysis

According to (Wagle, 1967), sensitivity and scenario analysis were originally developed and widely used as methods to analyze uncertainty in investments proposals.

Sensitivity analysis examines a project's or a valuation model's sensitivity for the changes in one key independent variable at a time. This allows to identify the most important or sensitive variables of a project and study how increase or decrease of the model's key variable affects the model's outcome. A particular case of sensitivity analysis is to calculate maximum (b), minimum (a) and mean (c) values of the key economic variable based on its optimistic, pessimistic and neutral estimates, which provides a solid yet limited range of possible results. As it was mentioned by (Wagle, 1967), the method suffers from the weakness that it does not provide any measure of the likelihood of obtaining any particular value. Additionally, Savvides (1994) emphasizes that sensitivity analysis relies on single values as and the method implicitly assumes that the values applied in a model are certain. Thus, the outcome is also presented as a certainty with no possible variance or margin of error associated with it.

In comparison with a sensitivity analysis, a scenario analysis entails changing several yet also limited combinations of key variables at the same time. In a scenario analysis, the typical output is three results where all variables simultaneously take on one of the three hypothetical realizations (for example, three expected stock price: one for each of optimistic, pessimistic and neutral scenarios).

Savvides (1994) concludes that although this to approaches to uncertainty analysis imply reasonable underlying assumptions and might be useful, both tests are static and rather arbitrary in their nature. As one of the main disadvantages of these two methods (Reed and Stephan, 2010) also mention that none of them alone produces probabilities of success or failure for the wanted outcome.

1.3.2 Fundamentals of Monte Carlo Simulation

Simulation analysis allows for incorporating correlations between variables as well as several project perspectives and presents results as probability distributions. According to (Reed and Stephan, 2010), the main benefit of using simulations instead of traditional approaches is that this method overcomes the limitations of sensitivity and scenario analyses by examining the effects of all possible combinations of variables and their realizations.

Monte Carlo simulation is a computer-based simulation of a stochastic model repeated numerous times to estimate the probability distribution of the outcome of the stochastic model. It requires the user to estimate a probability distribution to reflect the uncertainty for each random variable. According to (Reed and Stephan, 2010), Monte Carlo as a simulation method overcomes the limitations of sensitivity and scenario analyses by examining the effects of all possible combinations of variables and their realizations, Simulation allows the analysts to assign for each key uncertain variable a probability distribution, which represents the range of possible values for each variable. Then, through random sampling of these distributions, determine the distribution of all potential outcomes that could occur under these uncertainties.

The general simulation process as a cycle that is repeatedly undertaken to perform the simulated calculations is presented in the Figure 1. Once all assumptions, including the probability distribution of the model's variables and related correlation conditions have been set, the computer randomly generates many sample paths of the model's components in accordance with all the assumptions made on the previous step. The process is repeated many times until a sufficient number of simulations is conducted. According to (Savvides, 1994; Mun, 2003), the more complex the distribution of the model's key variables and the greater number of variables, the larger the number of the simulations will be.

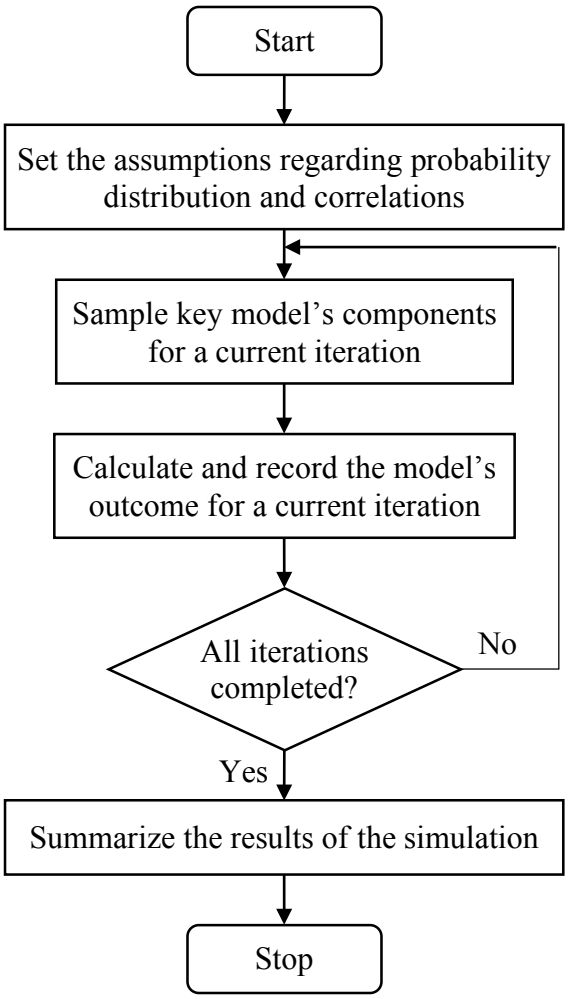


Figure 1. Monte Carlo simulation sampling process.

Source: made by the author.

Despite Monte Carlo simulation provides only an approximation of both the probability distribution and the corresponding parameters of the profitability criterion functions, it can be a useful tool for to visualizing risk for the decision-maker and detecting the inherent optimistic bias of project originators (Reed and Stephan, 2010). The decisions thus can be made with the knowledge of the whole distribution rather than one aggregate value, which ensures an adequate consideration of risk. Beside graphical formats, the simulation results are also reported various measures of location, dispersion, skewness, and kurtosis of the outcome distribution.

For acquiring the wider understanding of the uncertainty involved, one significant feature of Monte Carlo simulation is that it enables the modelling of very rare events as it allows for arbitrary probability distributions (Pedersen, 2013). Referring to the very rare events, Wagle (1967) states that "as far as extreme points of the distribution are concerned, the sampling approach is worthless" because "one may not be interested in the extreme values".

However, in this connection, it is reasonable to emphasize that uncertainty and risk are not the same thing. Many authors (e.g. Gonzalo and Olmo, 2004; Granger, 2002) emphasize that uncertainty of an event itself can be assessed by the variance in the event's probability distribution and is, as a concept, more objective than risk. In its turn, risk is produced by this uncertainty and its level depends on the decision-maker's interpretation. Two decision-makers may well react differently to the same extreme values in a distribution depending on their expectations and risk-aversion attitudes. Based on this (Reed and Stephan, 2010) highlighted another significant advantage of Monte Carlo simulation: it allows the decision-maker easily change its estimate on a scenario.

1.4 Linkage of residual earning valuation model with Monte Carlo simulation

Monte Carlo simulation is a widely applied method in capital budgeting analysis and investment appraisals (e.g. Reed and Stephan, 2010), yet less focus has been incorporated to stock valuation in the topic's academic research and literature. There are only a few studies analyzing incorporation of Monte Carlo simulation in different valuation models (for instance, Maged et al, 2008; Pedersen, 2013; Riikonen, 2016). Despite all authors agree that simulated valuation models usually set the estimated price closer to the observed in the market than original models, this issue has not been studied in general. All the studies mentioned above were focused on valuation of one or two particular companies and had case-studies as their research design. The main difference of this master thesis is that it is focused on the comparison of the simulated and original models in application to a range of companies conducted the IPO.

It might be also seen that Monte Carlo simulation method has a clear advantage in comparison with traditional methods such as sensitivity and scenario analysis. According to Reed and Stephan (2010), Monte Carlo simulation allows a decision-maker to address which variables are the most important. Pedersen (2013) also points out that Monte Carlo simulation is a useful tool when the probability distributions are not possible to derive analytically, either because it is too complex or because the stochastic variables of the model are not from simple, well-behaved probability distributions. Additionally, Hull (2014) points out that Monte Carlo simulation tends to be numerically more efficient than other procedures when there are three or more stochastic variables.

In respect of the residual income model, probability distribution and consistency of residual income are rarely available in financial statements and the notes of companies' annual reports. However, the model's key variables that compose the residual income may well have simple distributions with reliable means and variances. By using this, Monte Carlo simulation

involves the replacement of linear estimates of residual income for each year with probability distributions for the variables affecting the residual income, which reflects the uncertainty associated with the variable concerned.

Additionally, according to (Reed and Stephan, 2010), Monte Carlo simulation permits the analyst to specify correlations between model's key variables and quantify their effects on the outcome. These correlations allow variables to be linked across time (so-called serial correlation) or for one variable to be linked to another (so-called inter-variable correlation). Same as in (Riikonen, 2016), the simulation model constructed by the author does not contain specifications of correlations between the applied variables, but the practical functionality of the model is ensured by adding certain constraints and limitations. The following chapter of the thesis discusses the methodology used in the empirical research in more detail.

1.5 Summary of Chapter 1

Although there are some large companies that are still private, the initial public offering represents the first significant stage in the evolution of a public company that leads to a significant rise of capital and future growth opportunities. Initial public offering has become one of the most popular ways for companies across all industries and company sizes to acquire additional equity. It is, therefore, also one of the most popular topics for researchers.

In order to determine a fair price range within a company's stock will be offered to the public and, thereby, attract the largest possible amount of capital, it is crucial to have its stock valued before the IPO. There is a range of anomalies related to IPO pricing, such as IPO underpricing, long-term underperformance and cyclical nature of IPO. However, analysis of these anomalies lies out of the scope of this thesis since it is focused on the analysis of one of the valuation methods. All approaches to companies' valuation might be split into three categories: asset-based, market-based, and income-based approaches. Each of the approaches had certain advantages as well as limitations and it would be unreasonable to say that one of them dominates over the others in terms of applicability and/or accuracy of valuation.

Discounted dividends model, discounted cash flows model, and residual earning model are three examples of the income-based approach to valuation. There is no consensus which model is better in terms of setting the estimated price closed to the ones observed in the market. Many authors declare that, under several assumptions, all the models are equal to each over due to the fact that they have a common theoretical basis. It is worth to be mentioned that all model within income-based approach requires to forecast the model's future key variables and, thereby, deal with the uncertainty that characterizes future performance of a company.

One of the most advanced approaches to uncertainty analysis is Monte Carlo simulation. This method estimates the probability distribution of the model's outcome by simulating a stochastic model numerous times. This method overcomes the limitations of traditional approaches to deal with uncertainty – sensitivity and scenario analyses – by examining the effects of all possible combinations of variables and their realizations. Moreover, the Monte Carlo simulation is a more useful tool rather than traditional approaches since it provides decision makers with more detailed information on various measures of the outcome distribution, such as measures of location, dispersion, skewness, and kurtosis of the outcome distribution.

The methodology used in the empirical analysis, data collection process, results of the experiment, and key findings of the research are discussed in the following chapter.

CHAPTER 2. EMPIRICAL RESEARCH ON IPO VALUATION

This chapter firstly discusses the methodologies that will be applied in the empirical part and states the hypotheses of the thesis. Results of the empirical study are described and discussed at the end of the chapter.

The framework of the empirical study discussed below shows the key stages of the empirical research, which would provide the reader with statistically significant results, which would afterward serve as a basis for further discussion of the managerial implication of the research findings. The empirical study framework consists of four steps: theoretical framework and literature overview, empirical research methodology – including hypotheses formulation, data collection, and variable measurement – models fitting, and results analysis.

2.1 Methodology and hypothesis formulation

The section introduces three hypotheses of this master thesis and discusses the methodology applied in the conducted empirical research. Methodologies of each out of three steps of analysis are described in more details in the following sections.

First, in order to assess the general applicability of the Residual Earnings Model, multiple linear regression analyses for the companies within the collected sample is conducted. This regression analysis was performed in order to determine whether the residual earning model's key variables – earnings and book value of equity – actually have statistically significant explanatory power to companies' market values on the IPO date. In the regression analyses, the key variables act as the independent explanatory variables and the IPO prices – as the dependent variable. Therefore, the first hypothesis of the thesis will be as follows:

H1: Earnings and book value for the year prior to IPO have statistically significant explanatory power to companies' market value on the IPO date.

In order to test the statistical significance of the residual earning model's key variable the 10% significance level will be used.

Then, earnings and equity book value forecasted based on historical accounting numbers will be placed in the general RE model. Based on the historical performance of the companies, the general RE model's applicability will be assessed by recalculating the market value of companies and then compared to the observed market value on the IPO date. The incorporation of uncertainty, which is conducted by including the probability distributions of the key variables with the help of Monte Carlo simulation is yet excluded in this part. The purpose of this part will

be to set an initial framework for the further assessment of the simulated RE model. Thus, hypotheses of the thesis devoted to the original RE model analysis will be as follows:

H2.1: Original residual earning model provides with unbiased estimation of market value on the IPO date.

H2.2: Original residual earning model sets the recalculated market value close to the actual market value on IPO date.

In order to determine, whether the recalculated market value is 'close' to the actual one, the relative difference between recalculated company's value and the one observed in the market on the IPO date was analyzed.

After the general assessment of the original RE model, probability distributions of the model's key variables among other assumptions discussed in more detail below are added to the model in order to construct the simulated valuation model. For the sake of consistency in the conducted analyses, the assumed variables (for example the discount rates, perpetual growth rates and linear growth rates of the key variables) remain the same in both cases. The fundamental idea behind the analysis is to examine whether the simulated RE model provides an investor with more detailed and accurate information on companies' market values on the IPO date in comparison with the original RE model. Therefore, the hypotheses of the thesis devoted to the analysis of simulated RE model will be as follows:

H3.1: Simulated residual earning model provides with unbiased estimation of market value on the IPO date.

H3.2: Applying simulated RE model provides investors with more accurate information on market value on the IPO date in comparison with the original RE Model by generating estimated market values that are closer to the actual market values on the IPO date.

Finally, the results of both the original and the simulated RE model will be compared with the actual closing stock prices at the IPO date.

In order to conduct the above-described analysis, further analysis will be split into four steps: acquisition of sample, analysis of value relevance of residual earning model's key variables, analysis of the original residual earning model, analysis of the simulated residual earning model. The methodology used on each of the steps is discussed separately in the following sections.

2.2 Model description

2.2.1 Value relevance of residual earning model's key variables

As the initial stage of analysis of original and simulated RE models and their applicability, the explanatory power of the models' key variables – net income and book value of equity – on the market values on the IPO date is studied in this section.

The simplified regression model, which appears in most studies of 'value relevance' (Lee, 1999) is the following:

$$MV_j = a_0 + a_1 BV_j + a_2 NI_j + e_j \quad (1)$$

where the MV_j is the market value of a company j on the IPO date; BV_j and NI_j are the are book value of equity and net income or earnings of a company j for the year prior to the IPO; a_0, a_1 and a_2 are the coefficients of the regression model and e_j is the error term for a company j.

However, the scale-related effects derived from the differences in companies' size would result in biased estimates of the coefficients of the model and, for example, unrealistically high explanatory power of the model. Additionally, due to the size differences, the model would deal with heteroscedasticity problem, that is differences in variance in its error terms depending on the size of the company. In order to eliminate the mentioned effects, the model is scaled by dividing both sides of the equation by BV_j. It is also reasonable since earnings better explain firm value when the ratio of earnings to book value of equity is high. This modification of the model is also one of the reasons why companies with zero or negative book values of equity for the year prior to the IPO should be eliminated from the sample. Thus, the scaled regression model is as follows:

$$\frac{MV_j}{BV_j} = a_1 + a_0 \frac{1}{BV_j} + a_2 \frac{NI_j}{BV_j} + e_j \quad (2)$$

Additionally, in order to study the linear relationships between the two key variables and the market values, the thesis conducted the correlation analyses. The guidelines on strength of the relationships presented in the Table 2 were applied:

Table 2. Strength of linear relationship between model's variables.
Source: Riikonen, (2016).

Strength of relationship	Value of correlation coefficient
None or very weak	-0.1 to 0.1
Weak	-0.3 to -0.1 or 0.1 to 0.3
Moderate	-0.5 to -0.3 or 0.3 to 0.5
Strong	0.99 to -0.5 or 0.5 to 0.99

Strength of relationship	Value of correlation coefficient
Perfect	Exactly -1.00 or 1.00

Pearson's r and Spearman's ρ correlation coefficients were determined and are discussed in more detail in the empirical part of the thesis.

2.2.2 Original residual earning model

First, in order to set the initial framework for the further analysis, the applicability of original RE model is examined. The analysis is conducted based on the historical accounting numbers published in the audited financial statements for the financial periods of three years prior to the year when a company went through IPO process. The accounting numbers are used for the forecast of RE model key variables and the expected market value of a company on the IPO date is as it is described below. After the calculation, companies' expected market values generated by original RE model are compared with the actual market values at the IPO date.

The RE model applied in the analysis is presented in the equation below.

$$MV_0 = BV_0 + \sum_{t=1}^{n} \frac{NI_t - r_E * BV_{t-1}}{(1+r_E)^t} + \frac{T_n}{(1+r_E)^n} \quad (3)$$

However, the specific assumptions that apply to both the original and the simulated RE model are worth a closer examination. Therefore, the thesis discusses the assumptions regarding the valuation below.

CAPM and the related variables

The required rate of return for the case company's equity capital r_E is determined by the widely used capital asset pricing model or the CAPM: $r_E = r_f + \beta_E(r_m - r_f)$ and acts as the model's discount rate. It is used as the final discount rate for expected future abnormal earnings and it remains constant in forecasts (Lipe, 1986) for each particular valuation year. In this study, cost of equity r_E and, thereby, all the related variables of CAMP should be calculated for each company within the sample. The annual return of 10-years government bonds were taken as the risk-free rate r_f. As regards to the other variables of the CAPM, the risk equity premium $(r_m - r_f)$ and company's beta β_E were calculated based on the data from Damodaran Online website for each year over the analyzed period. In order to calculate β_E, the bottom-up approach is used. That is, all the companies within the sample are attributed to one of the industries used by Damodaran according to their USIC code. Data on industry average unlevered beta $\beta_u^{industry}$ and the efficient tax rate $\tau^{industry}$ is gathered from the Damodaran database, and the final β_E used in CAPM are calculated by the following formula:

$$\beta_j = \beta_u^{industry}\left(1 + \left(1 - \tau^{industry}\right)\right)\left(\frac{D_j}{E_j}\right) \quad (4)$$

Where β_j is the β_E used in CAPM model in order to determine cost of equity for company *j*; D_j and E_j are total debt and total equity respectively of company *j* for the year prior to the year when the company went through IPO process.

Expected growth rate of RE model key variables

Companies' net income or earning (hereinafter also referred as the "NI") and their book value of equity capital (hereinafter also referred as the "BV") at time zero or $t-1$ are the actual recorded values for the particular item extracted from each particular year's financial statements and act as the basis of the analysis. The expected growth rates for these key variables of the original RE model are assumed to be constant and equal to the linear growth of the respective variable during the N-year period prior to IPO process. The expected growth rates for companies' net income and their book value of equity is calculated as presented in the equations below.

$$E\left(NI_{growth\,rate}\right) \sim \left(NI_{t-1}/NI_{t-N-1}\right)^{1/N} - 1 \quad (5)$$

$$E\left(BV_{growth\,rate}\right) \sim \left(BV_{t-1}/BV_{t-N-1}\right)^{1/N} - 1 \quad (6)$$

Where $E\left(NI_{growth\,rate}\right)$ and $E\left(BV_{growth\,rate}\right)$ are the expected growth rate for companies' net income and book value of equity respectively used in the original RE model; NI_{t-1} and BV_{t-1} are the net income and book value of equity of a company for the year prior to the year when company performed IPO; NI_{t-N-1} and BV_{t-N-1} are the same items for the beginning of N-year period; N is the number of years within the period the forecast is based on. Based on the data availability, the parameter N was chosen to be equal 3; therefore, a three-year period prior to the IPO was used for the estimation of expected growth rates of the models' key variables.

Other considerations

One crucial consideration that should be taken into account is the reliability of the expected growth rate estimation based on the historical data. A negative value of the model's variable for one of the years used in the estimation process with the positive value for the next year will entail the growth rate to be more than 100%. This would result in unreasonably high expected growth rate which does not correspond to the company's future performance and disturb the valuation outcome. In order to avoid this problem, companies with a negative value

of the model's key variables – net income and book value of equity – for at least one year over the three-year period prior to IPO were excluded from the sample.

Since the $BV_{t+1} = BV_t + NI_{t+1} - D_{t+1}$, the valuation models are constructed in a way that the distribution of wealth to the firm's shareholders cannot result in negative values yet the author acknowledges that a negative D_{t+1} may in real life indicate that a company has issued additional shares. However, this concerns more the simulated model than the original RE model as the growth in the key variables are assumed to grow linearly and the deviations of the variables are yet excluded from the original model.

2.2.3 Simulated residual earning model

In this sub-section, the thesis discusses how the stock valuation model that applies Monte Carlo simulation to the RE model is constructed and the following analyses conducted. The logic of simulated RE model is the same as in the prior research on this topic (e.g. Pedersen, 2010 and Riikonen, 2016). Despite that this paper analyses general applicability of simulated RE model to stock prices valuation and not its applicability to a particular company or index, all the assumptions regarding the mathematical model are still the same.

Assumptions regarding the simulated residual earning model

Companies' net income or earning (hereinafter also referred as the "NI") and their book value of equity capital (hereinafter also referred as the "BV") at time zero or $t-1$ are the actual recorded values for the particular item extracted from each particular year's financial statements and act as the basis of the analysis. The expected growth rates for these key variables of the simulated RE model are assumed to be normally distributed as presented in the following equations:

$$E\left(NI_{growth\,rate}\right) \sim N(X_{NI}, \sigma_{NI}^2) \tag{7}$$

$$E\left(BV_{growth\,rate}\right) \sim N(X_{BV}, \sigma_{BV}^2) \tag{8}$$

Where the sample mean X_{NI} and X_{BV} are determined by the linear CAGR of the respective variables during the N-year period prior to IPO process. The growth rates' variances σ_{NI}^2 and σ_{BV}^2 are determined by calculating the standard deviations σ_{NI} and σ_{BV} of the annual growth rates of respective variables over the same N-year period.

The simulated RE model is constructed so that each particular year's outcome is determined by the randomly generated number representing each particular event's probability, the mean or the expected value and the standard deviation of each key variable. As it was

discussed above, the residual income at time *t*: $RI_t = NI_t - r_E * BV_{t-1}$ or the model's numerator for the year *t* might also have a negative value. This might occur in one of the two following scenarios:

i. The result of a Monte Carlo simulation at a particular time *t* lead to a negative value of net income or a loss;
ii. The result of a Monte Carlo simulation at a particular time *t* lead to the situation where a required return $r_E * BV_{t-1}$ is higher than the net income NI_t.

Therefore, the simulated RE model may generate a negative expected market value as one of the forecasting periods may result in a loss due to the nature of the simulation. This issue and its temporary nature will be discussed in more detail in the following section of the master thesis.

Structure of the simulated residual earning model

The construction process of the simulated RE model is as follows:

i. Inputs: probability distribution of annual growth in NI and BV
ii. Random number generator
iii. Simulation with described constraints
iv. Outputs: probability distribution of company's market value

Thus in addition to the applied mean or the expected growth rate, the simulation takes into account the variable's probability distribution including its standard deviation. After setting the bounds, the simulation generates a value within this distribution by applying the random number generator. The following forecasting periods are determined correspondingly yet with some noteworthy adjustments discussed in more detail below.

Taking into account the constraint described at the end of the previous sub-section, the simulated RE model is constructed so that the final and applied value for the equity at time t (BV_t) in the model is the lowest of the following:

i. Simulated $NI_t + BV_{t-1}$;
ii. Simulated BV_t.

This is based on the constraint $BV_t = BV_{t-1} + NI_t - D_t$, where $D_t \geq 0$. In other words, the model assumes that the firm cannot distribute a negative amount of wealth in form of dividends. Noteworthy, the author acknowledges that a negative D_{t+1} may in real life indicate

that a company has issued additional shares. However, taking into account the stability and solvency of the case company, this option is excluded from the model.

One of the most prominent advantages of the simulated RE model in comparison with the original model is that the simulation enables an analysis of a situation in which the key variables decrease. Thus, it corresponds to reality more comprehensively.

Example of the result generated by the simulated residual earning model

This sub-section presents a result generated by the simulated residual earning model on the example of Bakkavor Group which is nowadays a leading producer of fresh prepared food in the UK with a growing presence in the US and China.

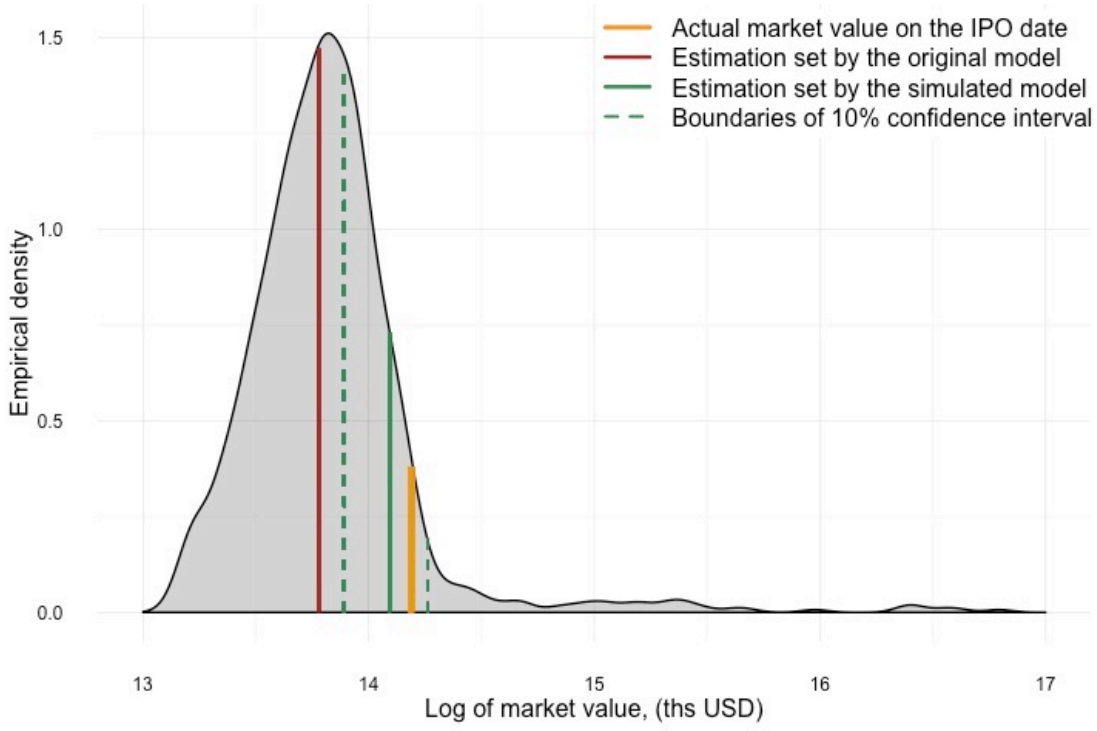
Bakkavor was founded in Iceland by two brothers, Agust and Lydur Gudmundsson in August 1986 to manufacture and export fish products. In 1997, the company listed on NASDAQ OMX Iceland Stock Exchange. In 2000-2004, the company acquired Wine & Dine and Katsouris Fresh Foods in the UK, sold its seafood operations and focused on fresh foods production. By 2008, the company had acquired several businesses in England, Europe, the United States and Asia. After the financial crisis, in 2009, the company delisted from the NASDAQ OMX Iceland and converted into a private company. Throughout 2010-2016, the company significantly expanded due to the acquisition of competitors and simplification of the corporate structure. In addition, the company's headquarters was moved from Reykjavík, Iceland to London, UK. In February 2016, the Baupost Group, another company owned by Agust and Lydur Gudmundsson, became a significant shareholder of the Group. Finally, The Bakkavor Group was listed on the London Stock Exchange in November 2017.

In an interview for the London Stock Exchange Group, Simon Burke, independent non-executive chairman of Bakkavor, said: "Over the past 30 years Bakkavor has grown to become the clear leader in the UK market for fresh prepared foods and a vital partner for retailers and food service companies. I have been impressed by the significant growth that Bakkavor has delivered as a private company. Now, with solid foundations in place for the next stage of the Company’s development, Bakkavor is excellently positioned to continue to build on its success and capitalize on the growth opportunities ahead”.

On the first day of public trade, the company's market capitalization reached 1,452 million of US dollars. The results of the simulated model and the original models are presented on the Figure 2. After numerous iterations, the simulated residual earning model generates a distribution of all the possible outcomes as discussed in the second chapter in more details. The

shadow area in the Figure 2 denotes the approximation of empirical density function of the simulated residual earning model outcome. The green line denotes the expected market value of the company set by the simulated model; the two dotted green lines of the same color denote 10% confidence interval boundaries of the estimated value. The red line and the yellow line denote an estimation set by the original model and the actual market value on the IPO date respectively.

Figure 2. Results of the simulated and original model applied to valuation of Bakkavor Group. Source: made by the author.



As it can be seen on the graph, the original model of residual earning, which is based on historical financial data of the company over the three-year period prior to the IPO, gives a greatly understated estimate equals to 946 million of US dollars (deviation of -33.6% from the actual market value on the IPO date). The estimate set by the simulated model is 1,319 million of US dollar, its deviation from the actual market value of the Bakkavor Group is -9.2%, which is significantly lower than the deviation of the original model outcome. This example demonstrates the superiority of the simulated model over the original one.

The density chart of the company's market capitalization distribution resembles a normal distribution with the so-called long right tail, which corresponds to the company's higher performance compared with the average case. Monte Carlo simulation builds its estimation based on numerous iterations and, thereby, allows constructing a probabilistic distribution of output data that considers rare cases and increase an accuracy of estimation. The original model

is based on simpler assumptions and does not consider uncertainty associated with the behavior of the company future performance and the original model's key variables. As the result, the original model sets the expected market value with lower accuracy: its estimation has a higher deviation from the actual market price of the Bakkavor Group on the IPO date in comparison with the estimation by the simulated model.

As it was mentioned earlier, incorporation of the Monte Carlo simulation in the residual earning model has other advantages. Firstly, one of the most prominent advantages is the visualization of all possible outcomes as probability distribution itself. This creates a convenient tool for visual analysis of the model: an investor can easily detect the possible inherent biases and reassess their estimates. Secondly, the simulated model allows to construct confidence intervals for the estimated value. This tool helps to analyze a scale of possible deviations from the expected value and a probability of such deviations. As it can be seen on the Figure 2, 10% confidence interval covers the actual market value of the Bakkavor Group on its IPO date.

2.3 Acquisition of data

2.3.1 Data collection

Due to the popularity of London Stock Exchange for companies' IPO, companies went public on London Stock Exchange (LSE) and London AIM Stock Exchange (LSE AIM) was chosen as the subject of empirical research. The initial sample was formed based on the IPO database Zephyr and included 492 companies went public during the period from 2010 to 2017 and primarily traded on these two stock exchanges.

The next step is a collection of the data from companies' financial statements for the years prior to public offering and all the relevant data for the residual earning model. In order to do that, Thomson Reuters and Damodaran databases were used. The companies with no available information needed for this study were excluded from the consideration. Additionally, companies which do not match the criteria regarding accounting information availability and/or inputs criteria for original and simulated residual earing models were excluded from the sample. The final number of the companies in the data sample is 58, including 18 companies performed IPO on London AIM Stock Exchange and 40 companies went public on London Stock Exchange. The Table 3 summaries the selection process.

Table 3. Number of companies in the data sample and selection criteria applied.
Source: author's calculations.

Criteria applied	Number of companies
Went public on LSE and LSE AIM from 2010 to 2017	492
Availability of data on accounting numbers for three-years period prior to the IPO	269
Non-negativity of model's key variables	58

2.3.2 Sample description

Although only about 12% of the companies from the initial sample fit all the requirements of the research, the 58 companies used for the empirical research are discussed below. This section presents information on companies in a generalized form. A complete list of companies with key information on them can be found in Appendix 1.

The distribution of companies among industries was analyzed. There is no predominant industry of the companies chosen for the analysis: 58 companies operate in 27 industries in total. The main categories are Healthcare Products (6 companies or 10.3% of the sample) and Business and Consumer Services, Financial Services, and Transportation (4 companies or 6.9% of the sample each). It is worth to be mentioned here that each company was attributed to one of the industries used by Damodaran in his database based on the company's Standard Industrial Classification code.

The number of companies that went public in each of the years from 2010 to 2017 is presented in Table 4. The thesis points it out that, although for some companies the data from the financial statements was available for a longer period than for other companies, the only three-year period prior to an IPO was used as the inputs for both original and simulated model. This may reduce the accuracy of the valuation of a particular company, but this is necessary for a correct assessment of the models applicability to IPO valuation.

Table 4. Number of companies in the data sample by year of the IPO.
Source: author's calculations.

Time period	Year of the IPO							
	2010	2011	2012	2013	2014	2015	2016	2017
Number of companies	8	6	2	6	12	7	7	10

Descriptive statistics of the variables used in residual earning models and further analysis is presented in the Table 5. The thesis notes the great difference between book value of equity for the year prior to the IPO and market capitalization on the IPO date. There are two main

reasons for that. Firstly, a low minimal value of the book value is due to the fact that some companies within the sample (e.g. MANX Telecom and CSF Group) relied more on debt financing before the IPO. Secondly, this fact demonstrates the importance of IPO for a company as a way to attract additional capital for future development and the opportunities it provides.

Table 5. Descriptive statistics of variables used in the analysis.
Source: author's calculations.

Variable	Average	Standard deviation	Minimum	Maximum
Market capitalization on the IPO date	1,759,000	7,690,034	47,290	58,870,000
Book value of equity for the year prior to the IPO	382,500	1,337,630	496	8,176,000
Net income for the year prior to the IPO	50,460	173,665	555	1,282,000

Notes:
All money variables are in thousands of USD.

2.4 Empirical results

This section presents, discusses and interprets the empirical results of the conducted analyses. The methodology of the analyses was discussed in more details in the previous section.

First, the thesis presents the results of the conducted regression analyses, in which the market values of analyzed companies on their IPO date were regressed on the key variables – earnings and book values of equity – of the RE model for the year prior to the year when companies went through IPO process. The initial purpose of the regression analysis is to examine the value relevance of the presented bottom-line items by studying whether their variations explain the variation in the market values. According to the results of the regression analysis conducted earnings and book values of equity show statistically significant explanatory power to the market values and therefore are considered value relevant components.

Secondly, the thesis discusses the general applicability of the original RE model on the basis of the historical accounting numbers. Applied assumptions and the structure of the valuation model is presented and discussed in more detail in the methodology section. This analysis acts as an initial framework for the third analysis, in which the RE model is combined with Monte Carlo simulation. According to the results, the original RE model generates unbiased estimations of the market value on the IPO date. From this point of view, original RE model can be regarded as an applicable valuation method for companies performing IPO. However, the model does not set the recalculated market value within 10% deviation from the actual market value on the IPO date in the majority of cases.

The third analysis combines the first two analyses and links the theoretical framework of the original RE model into practice via Monte Carlo simulation and real-life accounting numbers. The purpose of the simulated RE model is to examine whether or not it provides an investor with more accurate information in comparison with the original RE model. According to the results, the simulated RE model does generate more accurate results in comparison with the original RE model in terms of variance of estimations. However, the simulated model is still unable to set the recalculated market value within 10% deviation from the actual market value on the IPO date in the majority of cases.

Acknowledged restrictions, challenges, limitations and other considerations regarding the analyses as well as propositions for future academic research are discussed in more detail in the next section.

2.4.1 Value relevance of earnings and book values to market values on IPO date

On grounds of the conducted regression analyses, both the earnings in relation to the book values of equity or the variable NI_j/BV_j and reverse value of book equity or the variable $1/BV_j$ for the year prior to the year company performed IPO showed clear statistically significant explanatory power to the market values. Therefore, there are no reasons to reject the first hypothesis of the thesis as is stated below.

H1: Earnings and book value for the year prior to IPO have statistically significant explanatory power to companies' market value on the IPO date.

The results of the conducted regression analyses concerning the scaled key variables' coefficients, the corresponding p-values of the model are presented in the Table 6. R Square of the model is 0.86, which indicates a good explanatory power of the model.

Table 6. Results of the regression analysis.
Source: author's calculations.

Variable	Estimates of regression coefficients	Standard error of estimates	p.values for regression coefficients
Intercept	2.863 e+00	5.133 e+00	0.579
$1/BV_j$	1.407 e+01	1.832 e+00	2.88 e-10 ***
NI_j/BV_j	2.270 e+05	1.587 e+04	< 2 e-16 ***
R^2	0.8628		
p.value for the model significance	< 2.2 e-16 ***		

Notes:
*** Denotes significance at 1% level

It is worth to mention here on the grounds of the regression analysis applied to the whole initial sample consisted of 492 companies performed IPO on London Stock Exchange and London AIM Stock Exchange over the period from 2010 to 2017, only the earnings in relation to the book values of equity or the variable NI_j/BV_j showed statistically significant explanatory power to the market values. Nevertheless, the further examination of the key variables' effect on the market values on the IPO date of the companies chosen for the analysis is statistically reasonable and justifiable.

Table 7 presents the Pearson and Spearman's correlation coefficients among the key variables of regression analysis. According to the analysis, the correlation between the MV_j/BV_j and $1/BV_j$ shows statistical significance and its strength is considered to be strong based on both Pearson's and Spearman's correlation coefficients. The linear relationship between MV_j/BV_j and NI_j/BV_j is lower but is still considered to be strong according to both correlation coefficients. The linear relationship between NI_j/BV_j and $1/BV_j$ varies from weak to strong depending on the correlation coefficient used for the analysis.

Table 7. Correlation analysis.
Source: author's calculations.

Pearson correlations, (n = 58)			
	MV/BV	$1/BV$	NI/BV
MV/BV	1	0.8459314 ***	0.5933162 ***
$1/BV$	0.8459314 ***	1	0.2638994 ***
NI/BV	0.5933162 ***	0.2638994 ***	1
Spearman correlations, (n = 58)			
	MV/BV	$1/BV$	NI/BV
MV/BV	1	0.8329693 ***	0.6787966 ***
$1/BV$	0.8329693 ***	1	0.6419453 ***
NI/BV	0.6787966 ***	0.6419453 ***	1

Notes:
*** Denotes significance at 1% level

2.4.2 Applicability of original residual earning model

As it is stated on the previous sub-section, there are no reasons to reject the first hypothesis of the thesis since the conducted regression analysis showed a statistical significance of the key variables of the residual earning model – earnings and book values of equity – on the market values within the sample of analyzed companies. Therefore, the further examination of the RE model's key variables is statistically reasonable.

The purpose of the analysis is to set the initial framework for the further assessment of the simulated RE model. Therefore, hypotheses of the thesis devoted to the original RE model analysis are as follows:

H2.1: Original residual earning model provides with unbiased estimation of market value on the IPO date.

H2.2: Original residual earning model sets the recalculated market value close to the actual market value of on IPO date.

In order to assess the accuracy of the model, the logarithms of estimated by original residual earning model market value and actual market value on the IPO date were calculated for each company within the sample and then their difference was analyzed. This is a commonly used approach for such kind of analysis which have two main advantages. Firstly, the difference of logarithms assesses the relative deviation of one value from another and is easy to understand: if estimated company's market value is equal to the one observed in the market, the difference of logarithms will be equal to zero. In a case when the model underestimates the company and the actual market value is higher than the estimated, the difference of logarithms will be negative. If the company was overestimated, the difference of logarithms will be positive. The second advantage of the logarithms is that it scales variables used for the analysis and makes it easy to visualize the companies of different size.

One-sample t-test was applied to the differences of the logarithms in order to test **H2.1**. Summary of the test results is presented below in the Table 8. Based on the analysis, there is no reason to reject **H2.1** on 10% level of confidence since p.value is higher than 0.1. Therefore, the original residual earning model is considered to set unbiased estimations of companies' market value on the IPO date.

Table 8. T-test for estimations by original residual earning model.
Source: author's calculations.

One-sample t-test for difference of logarithms of actual market value on the IPO date and estimation by original residual earning model	
Null hypothesis	True mean of the sample is not equal to zero
Alternative hypothesis	True mean of the sample is not equal to zero (two-sided test)
Mean of the sample	-0.1224682
p.value	0.1313
Conclusion	There is no reasons to reject the null hypothesis

However, only 4 and 14 out of 58 market values estimated by original RE model lies within 10% and 20% deviation from the observed market value on the IPO date respectively.

The thesis rejects the hypothesis **H2.2** and concludes that the original residual earning model cannot be considered as a plausible model which sets the recalculated market values close to the actual market values observed on the IPO date. Table 9 presents the descriptive statistics of the comparison of actual market values on the IPO date and estimated by the original residual earning model. The discussion of the results and model's applicability to IPO valuation is presented in the next sub-section.

Table 9. Comparison of market values estimated by original residual earning model with actual market values.
Source: author's calculations.

Metric	Average	Standard deviation	Minimum	Maximum
Difference between logarithms of prices	-0.1225	0.6092165	-1.2040	2.1950
Difference between prices, %	1.1160	1.190617	0.3000	8.9770

2.4.3 Applicability of simulated residual earning model

The fundamental purpose of applying Monte Carlo simulation into the residual earning model is to assess whether it provides investors with more accurate information on companies' market value in comparison with the original residual earning model and in relation to the actual market value on the IPO date. Therefore, the hypotheses of the thesis devoted to the analysis of the simulated residual earning model are as follows:

H3.1: Simulated residual earning model provides with unbiased estimation of market value on the IPO date.

H3.2: Applying simulated residual earning model provides investors with more accurate information on market value on the IPO date in comparison with the original residual earning Model by generating estimated market values that are closer to the actual market values on the IPO date.

Similar to the previous sub-section, in order to test the **H3.1,** one-sample t-test was applied to the differences of logarithms of estimated by simulated RE model market value and actual market value on the IPO date. A summary of the test results is presented below in the Table 10. Based on the analysis results, there is no reason to reject **H3.1** on 10% level of confidence since p.value is higher than 0.1. Therefore, the simulated residual earning model is considered to set unbiased estimations of companies' market value on the IPO date.

Table 10. T-test for estimations by simulated residual earning model.

Source: author's calculations.

One-sample t-test for difference of logarithms of actual market value on the IPO date and estimation by simulated residual earning model	
Null hypothesis	True mean of the sample is not equal to zero
Alternative hypothesis	True mean of the sample is not equal to zero (two-sided test)
Mean of the sample	-0.01240762
p.value	0.8517
Conclusion	There is no reasons to reject the null hypothesis

Figure 3 visualizes results of the simulated residual earning model and compares the estimations with actual market values on a scatter-plot. A logarithm of actual market value on the IPO date goes on the x-axis; logarithm of the market value estimated by the simulated residual earning model goes on the y-axis. The grey line corresponds to the equation $y = x$. In a case when a company is valued with 100% accuracy two logarithms are equal to each over and a dot representing the company lies on the line. If the model overestimates the company's value and estimation is greater than the actual market value, a dot representing the company lies above the line. In case of underestimation, a dot lies below the line. It can be seen from the graph, some dots lie above the line, some of them – below the line, but in general the shape of dots' cluster follows the line. This shape corresponds with the conclusion regarding unbiasedness of estimations of the simulated residual earning model.

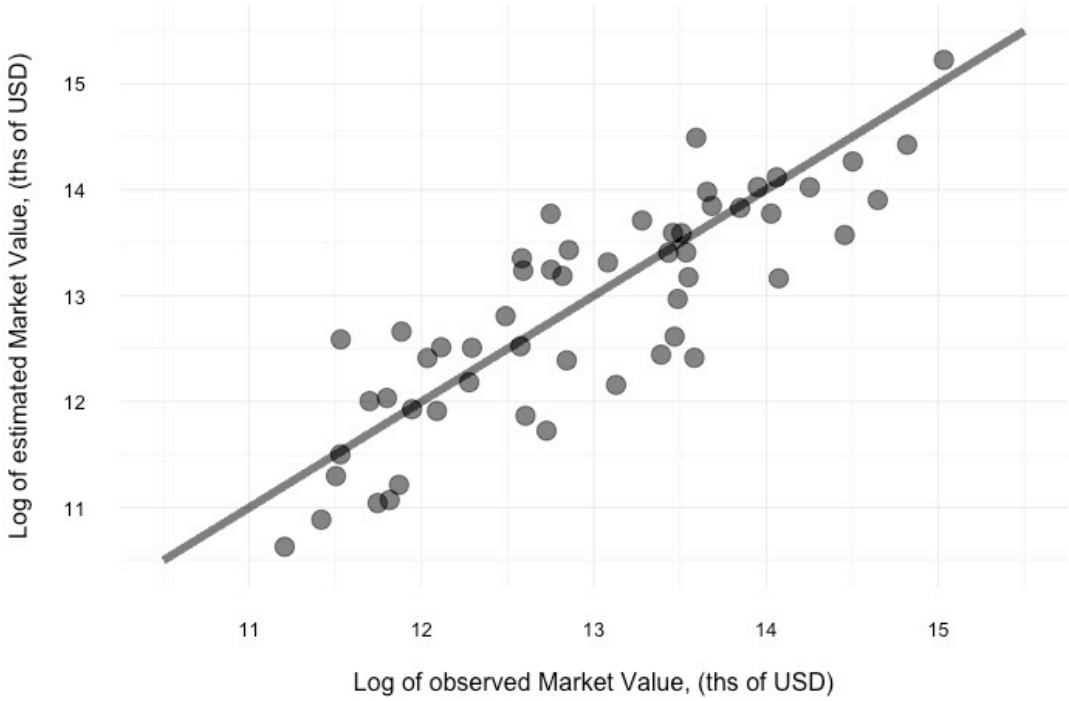


Figure 3. Results of simulated residual earning model.
Source: author's calculations.

Table 11 presents the descriptive statistics of the comparison of actual market values on the IPO date and estimated by the original residual earning model. With a visual comparison of the Table 11 and Table 9, it can be seen that the residual model sets the estimation that is closer to the actual market value on the IPO date. Formal tests for comparison of two model results and their analysis are presented further.

Table 11. Comparison of market values estimated by the simulated residual earning model with actual market values.
Source: author's calculations.

Metric	Average	Standard deviation	Minimum	Maximum
Difference between logarithms of prices	-0.01241	0.5030612	-0.88010	0.85260
Difference between prices, %	1.1150	0.549801	0.4147	2.4170

Since both models set unbiased estimation of the market value on the IPO date, it is reasonable to compare them between each other in terms of measures of location (or central tendency) and variation. In order to test **H3.2,** the following analysis was conducted: two-sample t-test for the means and f-test for the variance of log differences for the market values estimated by original and simulated RE models in relation with actual market values on the IPO date.

Firstly, two-sample t-test was applied to compare the means of two sample in order to check whether they statistically differ from each other. A summary of the test results is presented below in the Table 12. Based on the analysis results, there is no reason to claim that the mean log differences of original and simulated models are statistically different on 10% level of confidence since p.value is higher than 0.1. That is, original and simulated behave similarly to each other: although estimated values set by both models sometimes might be lower or greater than the actual market value, both models generate an unbiased estimation of actual market value on the IPO date without statistically significant difference between the models in terms of measures of central tendency.

Table 12. T-test for estimations by original and simulated residual earning models.
Source: author's calculations.

Two-sample t-test for difference of logarithms of actual market value on the IPO date and estimation by original and simulated residual earning model	
Null hypothesis	True difference in means of the samples is equal to zero
Alternative hypothesis	True difference in means is not equal to zero (two-sided test)
p.value	0.2911
Conclusion	There is no reasons to reject the null hypothesis

Secondly, f-test was applied to compare the variance of two sample in order to check whether simulated RE model generates a statistically better estimation of the market price on the IPO date in comparison with original RE model. A summary of the test results is presented below in the Table 13. Based on the analysis results, the estimations generated by simulated RE model have statistically significant lower variance. That is, simulated RE more often sets the recalculated market value closer to the actual market value on the IPO date in comparison with prices set by original RE model. Therefore, there are no reasons to reject hypothesis **H3.2**.

Table 13. F-test for estimations by original and simulated residual earning models.
Source: author's calculations.

F-test for difference of logarithms of actual market value on the IPO date and estimate of original and simulated residual earning model	
Null hypothesis	True ratio of variances is equal to 1
Alternative hypothesis	True ratio of variances is less than 1 (one-sided test)
Ratio of variances	0.6818648
p.value	0.07567
Conclusion	Reject the null hypothesis on 10% confidence level

Similar to results of the original residual earning model, only 4 and 14 out of 58 market values estimated by simulated model lies within 10% and 20% deviation from the observed market value on the IPO date respectively. One of the advantages of simulated model is its capability to set the confidence intervals for the estimated market values. The analysis of how this information can be used for the decision making is presented below.

In order to conduct the analysis, the empirical cumulative distribution function (ECDF) on a company's estimated market value and actual market value and their difference were calculated. In order to understand the logic behind the calculation, the same logic as for logarithm difference analysis should be used. If the company's market value on the IPO date is estimated with 100% accuracy, the difference of cumulative destitution function will be equal to zero. If the model overestimates or underestimates the actual market value, the difference will be positive or negative respectively. An absolute value of the difference also provides a valuable information on the accuracy of valuation: the closer the difference to zero, the better the simulated model catches the uncertainty effect on a company's market value. The ECDF values close to -1 or +1 means that even after uncertainty is incorporated in the residual earning model and a company's market value distribution is set, the model's estimation lies far away from the actual market value of the company.

Figure 4 visualizes analysis of empirical cumulative distribution function and presents the sorted values of ECDF differences for each company within the sample. Such visualization eases the analysis of confidence intervals. Dots on the graph, bounded by two black lines represent companies whose actual market values are covered by 10% confidence interval set by the simulated residual earning model. As it can be seen on the graph, only 12 out of 58 companies lie within the segment bounded by two black lines. Therefore, 10% confidence intervals cover the actual market value on the IPO date only for 10 companies out of 58.

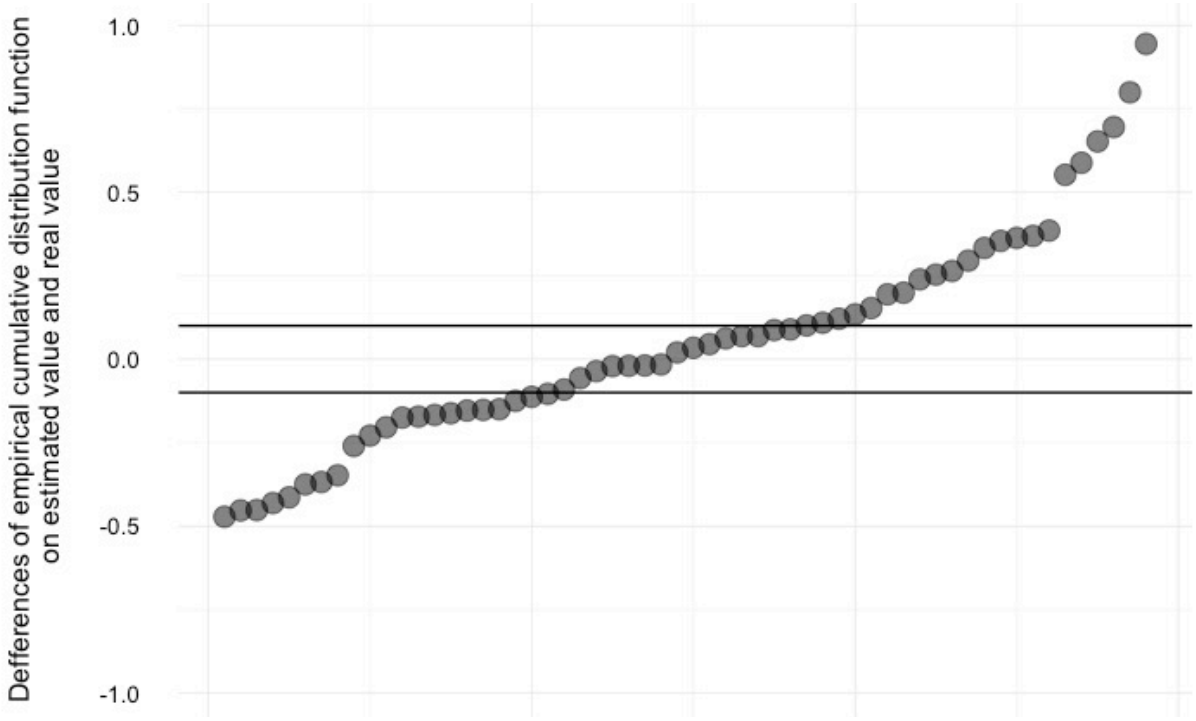


Figure 4. Difference of empirical cumulative distribution function on market value estimated by simulated model and actual market value on the IPO date.
Source: author's calculations.

The analysis of empirical research shows that simulated residual earning model has several significant advantages in relation to the original model. However, the plausibility of simulated model to IPO valuation is still an open question. Despite the hypothesis H3.2 was not rejected, same as the original residual earning model, the simulated model cannot be considered as a plausible approach which sets the recalculated market values close to the actual market values observed on the IPO date.

The results of the analysis of the two models and further discussion on the practical applicability of the models to the IPO valuation is provided in the next section of the thesis.

2.5 Discussion

2.5.1 Research findings

The first two research questions were stated at the beginning of the paper as follows: do the original and the simulated residual earning models generate an accurate expected value of a company on the IPO date? The results of the conducted empirical research do not allow to give a strict answer to these questions. From the one hand, the hypotheses **H2.1** and **H3.1** were not rejected. Therefore, the tests showed that both models generate unbiased estimations of companies' market value on the IPO dates. From another hand, the hypothesis **H2.2** was rejected due to the fact that the high variance and, thereby, low accuracy makes it unreasonable to use the original residual earning model as the only estimation while taking the decision.

As it was mentioned in literature survey, underwriters and investors never rely on one valuation technique: in order to estimate a fair value of a share before IPO, they apply different methods and then combine the value estimates. Hence, it was natural to expect that the model would not set the market value of a company with significant accuracy in all the cases. However, the estimated by both models and observed market values in some cases differ by several times and a question of applicability of the residual earning model to IPO valuation remains.

The third research question was stated as follows: does the simulated residual earning model provide related decision makers with valuable additional information on a market value of a company on the IPO date in comparison with original the residual earning model? In order to set the initial framework for further analysis of these two models, the relationship between their mean values was analyzed. As the test showed, there is no reason to claim that estimations generated by two models have different mean. This conclusion justifies the further comparison of the models. As it was shown in the previous section, the simulated residual earnings model has two main advantages over the original one. Firstly, the hypothesis **H3.2** was not rejected. The variance of estimations generated by the simulated residual earning model is lower in relation to estimations by original model; that is, simulated model sets the price that is close to the actual market value more often. Secondly, the simulated model allows to construct confidence intervals based on the probability distribution of the estimated market value.

Although the simulated residual earning model shows better results than its original analogue, it cannot be considered as a universal valuation tool due to a high relative deviation of estimates in comparison with actual market value. This finding contradicts previous researches on this topic. Pedersen (2010) and Riikonen (2016) applied the simulated residual earning model to the valuation of SP500 stock market index, Coca-Cola, and KONE companies. The authors

conclude that simulated residual earning model generates accurate and plausible stock prices in relation to the actual stock prices observed in the market. The thesis sees the different object of the studies as the main reason of this contradictions. In (Pedersen, 2010 and Riikonen, 2016) the simulated residual earning model was applied for recalculation of the stock prices of well-known companies with long history on the companies' performance and their stock prices volatility. This thesis sets the companies performing IPO as the main object of the research; the lack of information and high level of uncertainty about the future performance of a company make IPO valuation more complicated and lead to higher deviations of estimates from the observed market values.

Despite the shortcomings discussed above, application of Monte Carlo simulation is a useful modification of original residual earning model which provides decision-makers with valuable information regarding the IPO prices. Next sub-section discusses how key findings of this research can be applied in practice.

2.5.2 Managerial implications

Having discussed the results of hypothesis testing and their relations to the research questions, the thesis can highlight their possible interpretation from the business perspective. The results of the empirical study provide valuable insights for possible managerial implications which are explained in more details in this sub-section.

The most definitive implication of this study is a superiority of simulated residual earning model over the original one in relation to IPO valuation. As it is shown in the previous sections, the simulated model not only sets the market prices closer to the observed on the stock exchange, but also has additional advantages due to the structure of the model itself. Therefore, the simulated model can be used for estimation of the market value of a company that is going to become public through IPO.

As it was mentioned in the first chapter, issuers, underwriters, and investors are three main parties involved in an IPO process. All of them are interested in the most accurate estimation of a company's share price and can benefit from the model outcome itself. However, the thesis points out three possible ways to implement the simulated residual earning model.

An issuer of shares is interested in the maximization of attracted capital. In addition to a list of actions conducted at the preparation phase and aimed at changing internal processes within the company, the IPO's success requires a clear understanding of its position, demand for the company's shares and investors' interest in acquiring shares. In order to obtain this

understanding, it is necessary not only to accurately determine the fair value of the company, but also to determine possible deviations from the fair price for determining the range for the company's share offer price. Application of the Monte Carlo simulation application in the residual earning model represents the company's market value as a probabilistic distribution. Thus, this model allows to analyze not only the average value – the expected value of market value – but also deviations from it.

Moreover, the results of this model can be used by both issuers and underwriters in the negotiation process. For a number of reasons, in some cases underwriters allocate the issuer's shares in the primary market with a certain discount in order to increase the chances of successful IPO. The results of this simulated residual earning model can be used by underwriters in negotiations with investors at the primary market for determining the size of the discount and the final offer price.

Finally, public investors can use this model to make a decision about investing in a company that is considering to go public. The application of Monte Carlo simulation in the residual earning model not only allows to determine whether the company's shares are over- or under- priced, but also provides investors with additional information about the probability that the stock price may change by any value. Thus, each investor can make a decision based on the subjective perception of risk and the inclination to risk aversion.

At the same time, the thesis acknowledges the fact that neither of different valuation approaches described in the first chapter is superior to one another and, therefore, none of them should be used alone in order to make the final decision. Other limitations and concerns of this study as well as suggestions for further research are discussed in the next sub-section.

2.5.3 Limitations and suggestions for further research

The empirical research was aimed at testing applicability of Monte Carlo simulation in residual earnings model for IPO-prices evaluation. Although the research objective was reached, this study is subject to some limitations that are discussed in this sub-section.

First of all, the final number of companies in the data sample chosen for the empirical study might be perceived as the limitation for their representativeness. Despite this study covers all the companies conducted an IPO on London Stock Exchange and London AIM Stock Exchange over Moreover over the chosen period which meet all the criteria of selection, focus on London Stock Exchange does not allow to extend the findings to other markets. Nevertheless, the simulated residual earning model worked better than its original analogue within the

determined scope. Thus, it would be very interesting to study how the model applies to an extended sample of companies operating in other countries and traded on other stock exchanges.

The second limitation of this study concerns the simplified assumption of the model. For example, a company's compounded annual growth rates of net income and book value of equity and their annual standard deviations were based on historical accounting numbers extracted from financial statements of the company. Furthermore, the analyses conducted with the simulated residual earning model didn't take into account the development of economic conditions and development of the company itself. Plenborg (2002) specifies that the simplifying assumptions may significantly impact a firm's value estimates.

Although the assumptions behind the simulated residual earning model can be fairly regarded as simple and simplified, they are still a great improvement of the original model that does not incorporate probability distributions in its structure. Future research could focus on case studies as the simulated model and assumptions behind it can be adjusted to a particular company conducting an IPO and a forecast of its future performance. Another possible solution, which can be implemented in further research, is to conduct a comparable analysis by simulating the disaggregated items of and income statement (and, thereby, the models' key variables) and compare the results with the simulated model of this study.

The final concern of the thesis is related to the validity of the model. According to Sargent (1991), it is often too costly and time-consuming task to determine whether a model is absolutely valid over the complete domain of its intended applicability of not. He also specifies that there is no set of specific tests and rules that can be applied in order to determine the 'correctness' of a simulation model. Therefore, final assessment of the simulated model's applicability and market value estimations set by this model depends on the individual discretion of a decision-maker.

2.6 Summary of Chapter 2

In this chapter, the thesis conducted an empirical study which assessed the applicability of Monte Carlo simulation in the residual earning model for IPO-prices evaluation. The simulated residual earning model was proved to set the expected market value of a company conducting an IPO which is closer to the actual market price on the IPO date than an estimation set by the original residual earning model.

Based on the previous studies on this topic, five hypotheses were formulated. The first one test the significance on the residual earning model on the companies' market value on the

IPO date and sets an initial framework for further analysis. The following two hypotheses cover applicability of the original residual earning model for IPO-prices evaluation; the last two hypotheses are devoted to simulated residual earning model and its comparison with the original model.

The final data sample consists of 58 companies which had their IPO on London Stock Exchange and London AIM Stock Exchange from 2010 to 2017 and match the criteria regarding financial data sufficiency and compliance with the assumptions of the applied models. Among analyzed companies, 18 went public on LSE AIM and other 40 – on LSE.

The linear regression analysis on the model's key variable explanatory power over companies' market value on the IPO date has been conducted. The value relevance of the key variables was proved and, thereby, further research was justified. The original and simulated residual earning models were constructed and their applicability to IPO evaluation was tested.

Overall, it can be concluded that both original and simulated residual earning models generate unbiased estimations of companies' market value. It was also shown that the simulated model more often sets the recalculated market value closer to the actual market value on the IPO date in comparison with prices set by the original residual earning model. Moreover, it was shown that the simulated model allows to construct confidence interval and, thereby, analyze the deviation from the expected market value of a company conduction an IPO. However, due to a relatively high error of the estimations, none of these two models were recognized by the thesis as the universal and completely valid approach for IPO valuation.

CONCLUSION

One of the main interests of any company is to increase its value and increase shareholders' wealth. Initial public offering is one of the possible ways to attract an additional capital for the further development of a company. To determine the fair market value of the company and determine the price of the proposal, different methods are used. Residual earning model is one of the valuation methods which characterizes the value of a firm as the sum of its book value of equity and the present value of all the future residual income. In order to analyze an uncertainty regarding the future performance of a company conducting an IPO, Monte Carlo simulations can be used.

The main goal of this study was to analyze the application of Monte Carlo simulation to the residual earning model for IPO-prices evaluation and compare this modification with the original residual earning model. In order to analyze, how incorporation of Monte Carlo simulation as a tool for uncertainty analysis in a valuation model affects the model's outcome, five hypotheses have been tested:

H1: Earnings and book value for the year prior to IPO have statistically significant explanatory power to companies' market value on the IPO date.

H2.1: Original residual earning model provides with unbiased estimation of market value on the IPO date.

H2.2: The original residual earning model sets the recalculated market value close to the actual market value of on IPO date.

H3.1: Simulated residual earning model provides with unbiased estimation of market value on the IPO date.

H3.2: Applying simulated residual earning model provides investors with more accurate information on market value on the IPO date in comparison with the original RE Model by generating estimated market values that are closer to the actual market values on the IPO date.

The thesis performed the linear regression and constructed the original and the simulated residual earning model on the hand-collected data-sample of companies which went public on London Stock Exchange and London AIM Stock Exchange over the period from 2010 to 2017.

The results of the analysis allowed for both accepting and rejecting of some of the stated hypotheses and emphasized a superiority of simulated model over the original one in relation to the estimation of the market values of the companies went public on LSE and LSE AIM on the

IPO date. The conducted tests show that both original and simulated residual earning models set unbiased estimation of company's market value on the IPO date. In order to compare two models between each over, the mean value of the estimates and their variance were analyzed. Based on the findings, the thesis can conclude that the simulated residual earning model generates a more accurate estimation of companies' market value than its original analogue. It was also shown, that the simulated model has additional advantages due to the structure of the model itself.

All the parties involved in an IPO process should pay attention to the benefits the simulated model provides in comparison with the original one. Since issuers, underwriters and investors are interested in the most accurate valuation of a company's share price, they can use the simulated model and the advantages it provides for the decision making.

Given the context of the research and the scope of the topic, this study is subject to certain limitations, which show the directions for future research. The main limitations of this study include number and nature of the companies in the final data sample, simplified assumptions of the residual earning model and its reliability to accounting numbers. However, the paper suggests some destinations of further researches that can exceed these limitations.

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APPENDIXES

Appendix 1. List of companies analyzed in the empirical research

Company name	Company ticker	Industry	Deal stock exchange	Year of IPO	Market value on the IPO date
CAMBRIA AUTOMOBILES	CAMB	Retail (Special Lines)	LSE AIM	2010	90,968
CAPITAL DRILLING (DI)	CAPD	Oil/Gas (Production and Exploration)	LSE	2010	128,541
CSF GROUP	CSFG	Computer Services	LSE AIM	2010	152,203
EMIS GROUP	EMIS	Computer Services	LSE AIM	2010	306,801
SUPERDRY	SDRY	Retail (General)	LSE	2010	642,126
CPPGROUP	CPP	Business & Consumer Services	LSE	2010	675,619
JUPITER FUND MANAGEMENT	JUP	Investments & Asset Management	LSE	2010	1,108,981
ACACIA MINING	ACA	Metals & Mining	LSE	2010	3,548,913
ESCHER GROUP HOLDINGS	ESCH	Software (System & Application)	LSE AIM	2011	47,288
SECURE TRUST BANK	STB	Banks (Regional)	LSE	2011	171,565
SALVARX GROUP	SALV	Drugs (Biotechnology)	LSE AIM	2011	290,229
GLOBAL PORTS INVS.GDR (REGS)	GLPR	Transportation	LSE	2011	2,733,839
GENEL ENERGY	GENL	Oil/Gas (Production and Exploration)	LSE	2011	4,163,207
GLENCORE	GLEN	Metals & Mining	LSE	2011	58,874,782
NMC HEALTH	NMC	Healthcare Products	LSE	2012	678,179
DIRECT LINE IN.GROUP	DLG	Insurance (Prop/Cas.)	LSE	2012	4,489,049
KEYWORDS STUDIOS	KWS	Business & Consumer Services	LSE AIM	2013	88,571
SAFESTYLE UK	SFE	Furn/Home Furnishings	LSE AIM	2013	170,520
ARROW GLOBAL GROUP	ARW	Financial Svcs. (Non-bank & Insurance)	LSE	2013	621,820
STOCK SPIRITS GROUP	STCK	Beverage (Alcoholic)	LSE	2013	731,019
MEDICLINIC INTERNATIONAL	MDC	Healthcare Products	LSE	2013	1,033,977
FOXTONS GROUP	FOXT	Real Estate (General/Diversified)	LSE	2013	1,211,259
EASYHOTEL	EZH	Hotel/Gaming	LSE AIM	2014	96,742
NAHL GROUP	NAH	Software (Entertainment)	LSE AIM	2014	137,965
SHOE ZONE	SHOE	Retail (General)	LSE AIM	2014	142,304
XLMEDIA	XLM	Software	LSE AIM	2014	203,215

Company name	Company ticker	Industry	Deal stock exchange	Year of IPO	Market value on the IPO date
		(Entertainment)			
MANX TELECOM	MANX	Telecom. Services	LSE AIM	2014	293,737
GAMMA COMMUNICATIONS	GAMA	Telecom. Services	LSE AIM	2014	299,881
MCCOLL'S RETAIL GP.	MCLS	Retail (Grocery and Food)	LSE	2014	318,937
BCRE BRACK CAPITAL	BCRE	Real Estate (General/Diversified)	LSE	2014	382,286
FDM GROUP	FDM	Computer Services	LSE	2014	585,570
CAMBIAN GROUP	CMBN	Healthcare Products	LSE	2014	607,225
ONESAVINGS BANK	OSB	Financial Svcs. (Non-bank & Insurance)	LSE	2014	699,441
POLYPIPE GROUP	PLP	Building Materials	LSE	2014	836,685
SCS GROUP	SCS	Furn/Home Furnishings	LSE	2015	116,328
ELEGANT HOTELS GROUP	EHG	Hotel/Gaming	LSE AIM	2015	139,448
REVOLUTION BARS GROUP	RBG	Restaurant/Dining	LSE	2015	143,099
SANNE GROUP	SNN	Business & Consumer Services	LSE	2015	376,168
ON THE BEACH GROUP	OTB	Transportation	LSE	2015	427,255
INTERGRATED DIAGNOSTICS HOLDINGS	IDHC	Healthcare Products	LSE	2015	900,000
HASTINGS GROUP HDG.	HSTG	Insurance (Prop/Cas.)	LSE	2015	1,708,767
WARPAINT LONDON	W7L	Healthcare Products	LSE	2016	88,828
ACCROL GROUP HLDGS	ACRL	Furn/Home Furnishings	LSE AIM	2016	145,558
MIDWICH GROUP	MIDW	Business & Consumer Services	LSE AIM	2016	273,988
LUCECO	LUCE	Electrical Equipment	LSE	2016	291,652
FORTERRA	FORT	Building Materials	LSE	2016	514333
ASCENTIAL	ASCL	Software (Entertainment)	LSE	2016	1,289,211
COUNTRYSIDE PROPERTIES	CSP	Engineering/Construction	LSE	2016	1,523,772
GBGI	GBGI	Financial Svcs. (Non-bank & Insurance)	LSE	2017	163,969
MEDICA GROUP	MGP	Healthcare Products	LSE	2017	255,616
STRIX GROUP	KETL	Electrical Equipment	LSE AIM	2017	328,345
DP EURASIA N V	DPEU	Restaurant/Dining	LSE	2017	357,523

Company name	Company ticker	Industry	Deal stock exchange	Year of IPO	Market value on the IPO date
GLOBAL PORTS HLDG.	GPH	Transportation	LSE	2017	602,354
ADES INTL.HDG.	ADES	Oilfield Svcs/Equip.	LSE	2017	694,239
EDDIE STOBART LOGISTICS	ESL	Transportation	LSE AIM	2017	737,295
CHARTER COURT FINL.SVS.	CCFS	Financial Svcs. (Non-bank & Insurance)	LSE	2017	741,054
BAKKAVOR GROUP	BAKK	Food Processing	LSE	2017	1,452,364
CONTOURGLOBAL	GLO	Electrical Equipment	LSE	2017	2,211,418

Notes:
All money variables are in thousands of USD.